Ground beetle (Coleoptera: Carabidae) assemblages in the Conservation Reserve Program crop rotation systems in interior Alaska

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ABSTRACT

To improve knowledge of ground beetle communities and the influence of habitat succession on these communities in Alaska, adult ground beetle (Coleoptera: Carabidae) activity and diversity were documented on Conservation Research Program (CRP) agricultural lands in Delta Junction, Alaska (64° N, 145° W). Twenty species, comprising a total sample of 6,116 specimens, were collected during 2006 and 2007 from plots that were in the CRP for 9 years (young-field plots) and 19 years (old-field plots). Two species, *Cymindis cribricollis* Dejean and *Amara obesa* Say, are reported for the first time for Alaska. Species richness of carabids for our study plots was estimated, using the Chao 1 and Chao 2 estimators (Chao 1987), to be 22 and 28 species, respectively. Ninety-four percent of the specimens belonged to five species: *Pterostichus adstrictus* Eschscholtz (42.9%), *Agonum cupreum* Dejean (17.9%), *Calathus ingratus* Dejean (15%), *Amara obesa* (11.1%), and *Dicheirotrichus cognatus* (Gyllenhaal) (7.1%). Only *Ag. cupreum* showed significant effects based on plot age, with 7.5 times more specimens caught on younger plots. The majority of carabid activity occurred late in the season, from mid-September to early October. A comparison of our findings with historical data (1943–1956) from the collection of the Matanuska Experiment Station, in Palmer, Alaska, indicates that only three of the 44 carabid species from the historic Palmer collection are among the CRP fauna sampled.

Key Words: Alaska, beneficial, Carabidae, CRP, diversity

INTRODUCTION

Little is known about the beneficial insect fauna associated with Alaska's agricultural or natural systems (Hagerty *et al.* 2009). Given anticipated expansion of agriculture in Alaska and current trends in climate change, which is most pronounced in northern latitudes (Serreze *et al.* 2000; Chapin *et al.* 2006; Chen *et al.* 2011), it is important to establish baseline knowledge of the state's insect fauna from which subsequent comparisons can be made. Ground beetles (Coleoptera: Carabidae) have been used as ecological indicators for many years (Pearce and Venier 2006; Menalled *et al.* 2007; Work *et al.* 2008) and are also known predators of agricultural pests and seeds of weed plants (Lövei and Sunderland 1996; Kromp 1999; Harrison and Regnier 2003; O'Neal *et al.* 2005; Harrison and Gallandt 2012). Alaskan farmers have enrolled more than 10,000 hectares under the National Resources Conservation Service (NRCS 2003), Conservation Reserve Program (CRP), most of which is located near the city of Delta Junction to control erosion by wind (Schoephorster 1973; Lewis *et al.* 1979). Conservation Reserve Program land in other states has been positively correlated with wildlife diversity, including butterflies

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(Davros *et al.* 2006), birds (Johnson and Schwartz 1993; Millenbah *et al.* 1996; Best *et al.* 1997; Delisle and Savidge 1997), mammals (Chapman and Ribic 2002), and herptiles (Semlitsch and Bodie 2003).

The Conservation Reserve Program promotes the conservation of habitats beneficial to wildlife (NRCS 2003). However, participation in the CRP programs requires that CRP fields be mown every two to three years to slow succession to shrubs and trees (Seefeldt *et al.* 2010). Agricultural practices are known to affect the presence, activity, and abundance of ground beetles in agricultural settings (O'Rourke *et al.* 2008; Ward *et al.* 2011). However, despite the long history of CRP in Alaska (Seefeldt *et al.* 2010), little is known about the effects of CRP-management practices on ground beetles in the state. Additionally, due to the state's large size, remoteness, vast regions of roadless lands, and historic dearth of in-state entomological professionals, the insect fauna of Alaska is one of the most poorly documented in the US (Sailer 1954).

Few detailed descriptions of entire, extant carabid assemblages in Alaska exist. These include Lindroth's (1963) description of the carabids of the Aleutian Islands and studies on the carabid fauna of Kodiak Island (Ball 1969; Lindroth 1969b; Lindroth and Ball 1969). Most of the detailed assemblage descriptions are checklists, often lacking within-state locality or ecological data. The earliest Alaskan records are known from Russian coleopterist Mannerheim (1843, 1846, 1852, 1853). When Hamilton (1894) summarized the beetle fauna of Alaska, he reported 43 carabid species now considered valid. Schwarz (1900) of the Harriman Expedition reported 28 now-valid species. As part of an environmental impact statement prior to the planned, but later aborted, detonation of a multi-megatonne nuclear device, Watson *et al.* (1966) documented 19 species of carabids from the Cape Thompson region of Alaska. The most thorough treatments of the family for Alaska, including Canada, is the classic six-volume work by Lindroth (1969a). Bousquet (1991) listed 231 Alaskan species, and Bousquet and Larochelle (1993), listed 234 species. An excellent summary of the carabidae of the Yukon, which lists 209 species and includes syntheses of biogeographic and habitat data, was prepared by Ball and Currie (1997). However, these more recent synthetic works, from Lindroth (1969a) to Ball and Currie (1997), summarize data across vast regions rather than describe restricted assemblages as we do here.

This research was initiated to study the species composition, seasonal activity, and effects of plot age on dominant carabid species in CRP lands in Delta Junction, Alaska, and to aid state-wide efforts to document Alaska's entomofauna.

MATERIALS AND METHODS

Study Site. Land registered under the CRP near Delta Junction, Alaska, (64° N, 145° W) was surveyed for ground beetles. Eight plots were selected based on their time under the CRP program (Table 1). Plots were assigned to two age groups, with four plots per group according to the plot history under CRP management that Seefeldt *et al.* (2010) describe. Plots with nine years under the CRP program were grouped as young plots, while plots with 19 years under CRP management were considered old plots. Older plots have more disturbance events over time (mowing and weed control): this was expected to reduce the relative abundance of carabids.

The Seefeldt *et al.* (2010) report was also used to assign a litter cover to each plot (Table 1) and compare those parameters to relative ground beetle species' frequencies. Plots are located in the Interior Bottomlands Ecoregion of the Alaska boreal forest (Gallant *et al.* 1995), adjacent to the outwash plain of the Tanana River. The area ranges in elevation from 330 to 385 m; soils are silt loam (NRCS 2013). Surrounding forest vegetation is a mix of white and black spruce [*Picea glauca* (Moench) Voss and *P. mariana* (Mill.) Britton, Sterns & Poggenburg], balsam poplar (*Populus balsamifera* L.), quaking aspen (*Populus tremuloides* Michx.), and paper birch (*Betula papyrifera* Marsh.), with associated understorey species (Hulten 1968). Average winter temperature are between –2 and –4 °C, with frost-free periods typically lasting 80 to 120 days. The average July temperature is about 16 °C. Annual precipitation varies from

Table 1
Eight study plots near Delta Junction, Alaska, USA, on Conservation Research Program land.

Plot Number	Latitude	Longitude[a]	CPR time[b]	Area	Litter Depth (ha)(cm)[c]
11	63°59.203'N	145°18.940'W	old	44.33	73
15	63°58.710'N	145°20.100'W	old	54.85	70
25	63°58.058'N	145°08.221'W	young	36.18	83
26	63°57.925'N	145°08.480'W	young	36.18	76
27	63°57.454'N	145°10.154'W	old	44.60	80
33	64°00.391'N	145°07.040'W	old	46.22	73
37	64°01.883'N	145°07.265'W	young	63.36	73
39	64°01.276'N	145°07.727'W	young	21.50	87

[a] Geo-coordinates have a precision of +/– 150 m (WGS84 datum); elevation of all plots: 330–350 m.
[b] Years under CRP: old = 19 years; young = 9 years.
[c] Litter depts. As per Seefeldt *et al.* (2010).

250 to 300 mm. The study area was cleared from 1979 to 1982 as part of Delta Agricultural Projects (Lewis *et al.* 1979). Fields are farmed on a three-year rotation, with two years of spring barley or oats followed with one year of tilled fallow (Seefeldt *et al.* 2010).

Trap Methods. Insects were collected using pitfall traps, which are a standard method used to measure ground beetle activity density in both agricultural and natural systems (Southwood 1978; O'Rourke *et al.* 2008; Ward *et al.* 2011). Although often interpreted as measures of relative abundance, pitfall trap catches more accurately measure activity density and have been criticized for their demonstrable limitations and biases (e.g., Topping and Sunderland 1992; Melbourne 1999). Pitfall traps consisted of two plastic 480 ml containers (10.5 cm diameter X 7.5 cm deep), one inside the other. Holes were dug with a standard hand-held post-hole digger, and containers were placed in each hole so that the rim of the inner container was flush with the ground. The outer container had holes in the bottom to allow drainage. The inner container was filled approximately one-quarter full with a solution of 25 % propylene glycol. Each trap was covered with a white 23-cm-diametre plastic plate. Plates were held in place by three landscaping staples pushed through the top. The traps were placed in the field in a diamond pattern (approx. 1 m between each trap), using five traps within each of the eight plots, for a total of 40 traps. Traps were deployed as early as holes could be dug to set traps.

Insect counts from the five traps per site and sampling date were combined and considered as a sample for statistical analysis. Based on relative plant density, traps were placed in plot areas that seemed representative of the overall plot. Traps were emptied and reset on a weekly basis in 2006 and 2007. Sampling dates were 6 June to 20 October 2006 and 8 May to 28 September 2007. At times, voles were caught in traps.

Sample Processing. Samples were transported to the US Department of Agriculture (USDA), Agricultural Research Service (ARS) laboratory on the University of Alaska–Fairbanks campus and processed. Ground beetles were pinned and identified primarily by the third author, using methods described by Lindroth (1969a), Bousquet and Larochelle (1993), and Ball and Bousquet (2001). Most identifications were confirmed by George E. Ball (University of Alberta, Canada), Robert Davidson (Carnegie Museum of Natural History, Pittsburg, Pennsylvania), and Christopher J. Marshall (Oregon State Arthropod Collection, Corvallis, Oregon). Voucher specimens were deposited in the insect collection of the University of Alaska Museum (UAM), Fairbanks, Alaska. Records of these specimens are available online via the UAM database (Arctos 2013a). Species names follow the classification of Bousquet and Larochelle (1993), and Ball and Bousquet (2001).

Species Richness. EstimateS v8.2 (Colwell 2009) was used to calculate estimated species richness using nine estimators. Species-richness estimators allow one to extrapolate beyond one's data to infer the total number of species in these plots if sampling were continued using the same methods, thus providing an estimate of completeness. The results over the combined two-year sample for two of the most frequently used estimators, Chao 1 and Chao 2, were calculated (Chao 1987). Chao 1 is an abundance-based estimator, in that it uses the number of species represented by one or two individuals, whereas Chao 2 is an incidence-based estimator, in that it relies on the number of species found in only one or two sample units, regardless of the number of individuals (Chazdon *et al.* 1998).

Data Analysis. The number of insects per trap per 14-day period was calculated by combining weekly captures and used to present seasonal variation. Insect counts from the five traps per site were pooled for statistical analysis. Insect counts for species for which at least 50 specimens were collected during the two-year sampling period (O'Rourke *et al.* 2008) were analyzed using PROC GLIMIX (SAS 2008), and means were compared with the LSMEANS statement with the ILINK option. The Poisson distribution was used to model the counts, the Generalized Chi-square/DF was used to test fitness, and the Type III Tests of Fixed Effects were used to test significance for time under CRP.

Historic Data. The University of Alaska Museum Insect Collection (UAM) was examined to provide additional information on ground beetle species in Alaska. This collection, formerly housed at the Matanuska Experiment Station of the University of Alaska Agricultural and Forestry Experiment Station in Palmer, Alaska, is the only large agricultural insect collection maintained in the state (Washburn 1972). Some of the carabid records of the collection were published previously (Lindroth 1969a) and all of the species have been reported from the state by other workers. However, because this collection was assembled as part of early agricultural research in Alaska, we report the Alaskan records here for comparative purposes. Specimen data for these records are available via UAM's online database (Arctos 2013b). The majority of specimens housed in the UAM Insect Collection were previously identified by J. M. Valentine and C. H. Lindroth in the 1940s and 1960s, respectively.

RESULTS

Species Richness. A total of 6,116 specimens representing 20 species from 14 genera were collected (Table 2). The full set of estimators (±1 SD) yielded estimates that ranged from 19.7 to 28 species (Fig. 1): 22.8 (ACE); 23.8 ± 0.01 (ICE); 22.3 ± 3.4 (Chao 1); 28 ± 11.7 (Chao 2); 23.9 ± 1.9 (Jack 1); 26.8 (Jack 2); 21.7 (Bootstrap mean); 19.7 (MMRuns Mean); 20 (Cole Rarefaction; Colwell, 2009).

Activity Density. The total number of specimens from CRP plots was almost equal between years, with 3,099 and 3,017 specimens for 2006 and 2007, respectively (Table 2). However, *A. cupreum* specimens were 3.2 times more abundant in 2007 (n=828) than in 2006 (n=256), and *A. obesa* activity was 15.3 times higher in 2006 (n=644) than in 2007 (n=42). Ninety-four percent of the specimens belong to five species: *P. adstrictus* (42.9%), *A. cupreum* (17.9%), *C. ingratus* (15%), *A. obesa* (11.1%), and *D. cognatus* (7.1%). Two species, *A. obesa* and *C. cribricollis*, represent new records for Alaska.

A single species, *P. adstrictus*, was the predominant species in both years, representing 39.3% and 46.4% of total specimens collected during 2006 and 2007, respectively (Table 2). This species was captured equally in all plots, regardless of time under CRP management or litter depth

(Table 1). *P. adstrictus* was also the most abundant species in the historic data (Arctos, 2013b), with 58 specimens (Table 3).

Ground beetle activity density differed by the amount of time the plot had been under the CRP program, but was not affected by the depth of the litter cover on plots. However, the response varied by species (Table 1 and 4). All species with at least 50 specimens in each year in the total dataset were found in both old and young plots, but not in equal proportions. A significantly lower number (7.5 times less) of *A. cupreum* was recorded for plots with a long history (19 years) under the CRP

Table 2

Activity densities of 20 ground beetle species, for which at least 50 specimens were collected during the two-year sampling period from CRP land, sorted from most to least abundant. Percent within yearly totals and sums across both years are presented. Delta Junction, Alaska, USA, 2006–2007.

Species	%2006	%2007	Sum
Pterostichus adstrictus Eschscholtz	39.3	46.4	2616
Agonum cupreum Dejean	8.3	27.4	1084
Calathus ingratus Dejean	19.1	10.8	920
Amara obesa Say[a]	20.8	1.4	686
Dicherotrichus cognatus (Gyllenhaal)	8.1	6.1	435
Amara sp(p.)[b]	1.1	2.6	112
Carabus chamissonis Fischer	1	2.1	92
Asaphidion yukonense Wickham	0.4	1.3	52
Cymindis cribricollis Dejean[a]	0.7	0.5	37
Cicindela longilabris Say	0.7	0.5	35
Carabus vietinghoffii Adams	0.1	0.3	13
Bembidion sp.	<0.1	0.3	9
Miscodera arctica (Paykull)	0.1	0.2	8
Harpalus laticeps LeConte	0.2	<0.1	6
Notiophilus semistriatus Say	<0.1	<0.1	3
Amara hyperobrea Dejean	<0.1	<0.1	2
Syntomus americanus (Dejean)	0	0.1	2
Harplaus fulvilabris Mannerheim	<0.1	0	1
Harpalus somnulentus Dejean	0	<0.1	1
Pterostichus kotzebuei Ball	0	<0.1	1

n = 3099 and 3017 individuals for 2006 and 2007, respectively.

[a] New record for Alaska

[b] *Amara* sp(p.) confirmed as not *Amara obesa*

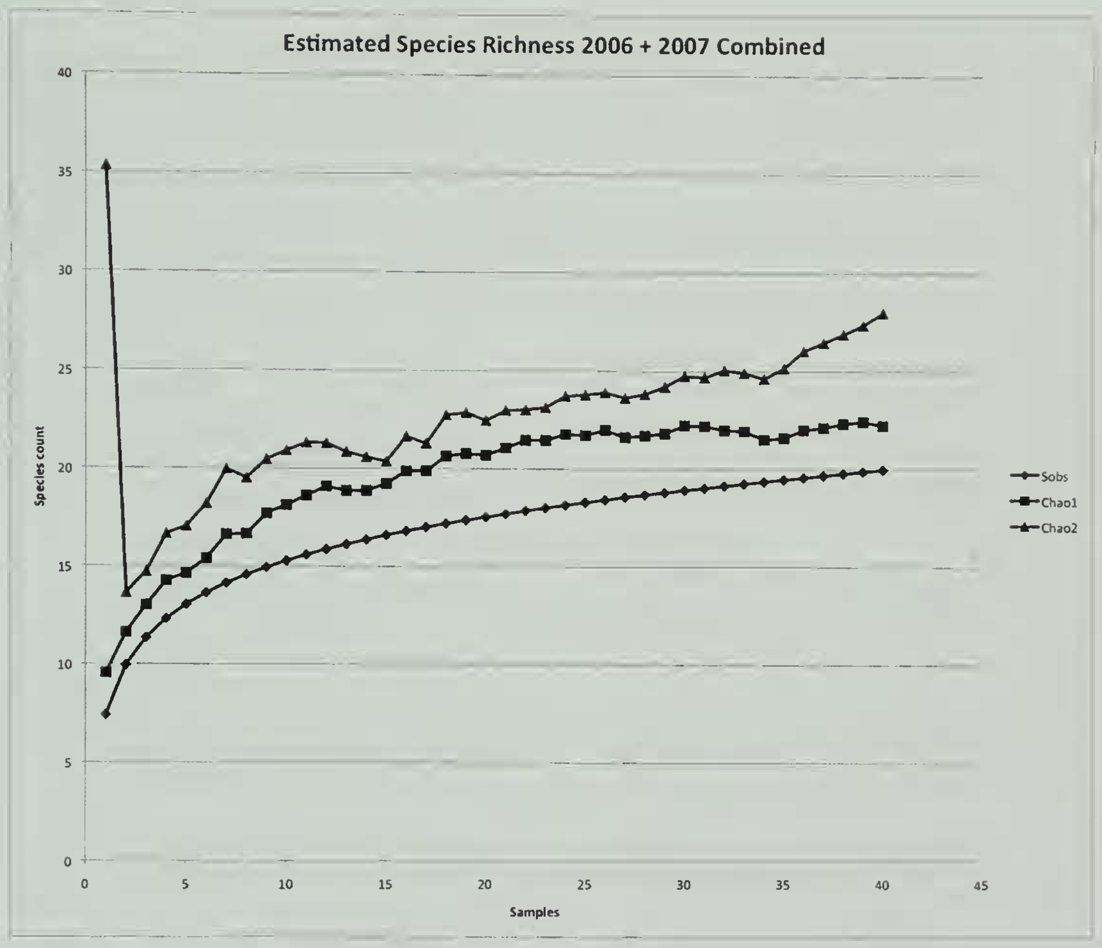

Figure 1. Carabid species richness estimates calculated using the Chao 1 and 2 estimators (Chao 1987) for combined 2006 and 2007 samples, from Delta Junction, AK, CRP land. At Sample 40, the means of each estimator were 22, 25, and 28, respectively. The observed species richness was 20 species obtained by Sample 27. Estimates were made using EstimateS v8.2 (Colwell 2009).

management, compared to plots with a mean of nine years under CRP (Table 4). However, frequencies of *A. obesa*, *C. ingratus*, *D. cognatus*, and *P. adstrictus* were not significantly affected by time under CRP management.

The maximum activity density observed was 32.9 *P. adstrictus* per 14-day sampling period for October 15, 2007. *Pterostichus adstrictus* was collected after first snowfall and can be active until early October. In 2006, snow/rain was registered as early as September 25, snow was registered by September 30, and insects were collected up to October 30 (Fig. 2).

Activity was observed from May to October (Fig 2). Traps were deployed as early as holes could be dug to set traps. During both years, ground beetles were active during the first week after traps were deployed, before the soils thawed. Depending on the year and species, ground beetle activity, as measured by the mean number of adults per 14-day period, started increasing rapidly in late September (2006) or late August (2007).

Historic Data. The UAM holdings from the Experiment Station, in Palmer, Alaska, which were assembled as an agricultural research collection, includes 44 confidently identified carabid species (Table 3). Three species occur in both the historic data and the CRP findings (*P. adstrictus*, *C. ingratus*, and *D. cognatus*). Phenology data from the historic sampling shows three peaks of activity, with both early (April 3) and late (November 17) records (Fig. 3).

DISCUSSION

Species Richness. The majority of estimators predict species richness close to our observation of 20, although some estimators, like the Chao2, indicate the fauna could be much richer than we sampled. The species-accumulation curve (Fig. 1) does not reach an asymptote, suggesting additional species in the community remain unsampled. The large

Table 3

Forty-four carabid species, based on 254 Alaskan specimens with confident determinations collected primarily by R. H. Washburn, G. W. Gasser, and J. C. Chamberlin between 1943 and 1956, held in the UAM Insect Collection, and formerly housed at the Matanuska Experiment Station of the University of Alaska Agricultural and Forestry Experiment Station, in Palmer, Alaska, USA. Specimen determinations were made primarily by C. H. Lindroth and J. M. Valentine. Specimen data available online via the UAM database (Arctos 2013b). Species sorted by number of specimens.

Species	No. specimens	Species	No. specimens
Pterostichus adstrictus Eschscholtz [a]	58	*Carabus taedatus* Fabricius	2
Amara patruelis Dejean	49	*Pterostichus empetricola* (Dejean)	2
Amara interstitialis (Dejean)	22	*Sericoda quadripunctata* (DeGeer)	2
Scaphinotus marginatus (Fischer von Waldheim)	11	*Amara littoralis* Mannerheim	1
Amara laevipennis Kirby	10	*Amara sinuosa* (Casey)	1
Calathus ingratus Dejean [a]	9	*Amara torrida* (Panzer)	1
Amara quenseli (Schonherr)	8	*Bembidion castum* Casey	1
Dicheirotrichus cognatus (Gyllenhaal) [a]	8	*Bembidion lapponicum* Zetterstedt	1
Harpalus somnulentus Dejean	8	*Bembidion mutatum* Gemminger & Harold	1
Amara erraticus (Duftschmid)	7	*Bembidion nigripes* (Kirby)	1
Agonum consimile (Gyllenhaal)	5	*Elaphrus clairvillei* Kirby	1
Amara lunicollis Schiodte	5	*Elaphrus purpurans* Hausen	1
Bembidion incertum (Motschulsky)	4	*Harpalus fuscipalpis* Sturm	1
Bradycellus nigrinus (Dejean)	4	*Loricera pilicornis* (Fabricius)	1
Elaphrus riparius Linneaus	4	*Nebria metallica* Fischer von Waldheim	1
Bembidion levettei Casey	3	*Nebria sahlbergii* Fischer von Waldheim	1
Elaphrus trossulus Semenov	3	*Opisthius richardsoni* Kirby	1
Pterostichus crenicollis LeConte	3	*Pterostichus castaneus* (Dejean)	1
Acalathus advena (LeConte)	2	*Pterostichus oregonus* LeConte	1
Bembidion bimaculatum (Kirby)	2	*Pterostichus pinguedineus* Eschscholtz	1
Bembidion grapii Gyllenhaal	2	*Sericoda bembidioides* Kirby	1
Bembidion obscurellum (Motschulsky)	2	*Sericoda bogemannii* (Gyllenhaal)	1

[a] Also collected from CPR field studies

Table 4
Mean number of ground beetles (±SE) with at least 50 specimens per year, in plots with different time under CRP management (years under CRP: old = 19 years; young = 9 years). Delta Junction, Alaska, USA, 2006–2007.

	Species				
	Ag. cupreum	*Am. obesa*	*C. ingratus*	*D. cognatus*	*P. adstrictus*
Young	6.0±0.9	4.6±1.2	4.4±1.0	1.8±0.5	7.6±4.4
Old	0.8±0.2	0.3±0.1	1.2±0.2	0.9±0.3	7.6±4.4
F value	12.18	6.45	0.89	0.84	0.00
P	0.0246	0.0707	0.4043	0.4325	0.9999
DF (Num/Den)	1 / 4.05	1 / 3.64	1 / 3.58	1 / 2.97	1 / 3.91

number of species with small counts (Table 2) also indicates sampling of this fauna is incomplete. Because these plots are not isolated habitats, a low number of "tourist" species, which pass through but do not breed or spend much time in the sampled habitats, are expected. However, the intent of this study was to document the dominant carabid species, which these estimators indicate we have done.

New State Records. Both of the two species, *A. obesa* and *C. cribricollis*, that are new records for Alaska are reported from all three major northwestern Canadian jurisdictions (YK, NT, BC) by Bousquet (1991), so their presence in interior Alaska is not surprising. Bousquet and Larochelle (1993) list *C. cribricollis*, but not *A. obesa*, as previously reported from Alaska, but based on doubtful record(s) that need verification.

Amara obesa is reported to prefer dry, usually sandy, soil with sparse vegetation (Larochelle and Lariviere 2003). This species was the fourth most abundant, with 686 specimens collected. Ninety-four percent of these specimens were collected in 2006.

Cymindis cribricollis is a similarly xerophilous species collected mainly from dry, sandy moraines with sparse or absent plant cover (Lindroth 1969a; Ball and Currie 1997; Larochelle and Lariviere 2003). In our study, 36 *C. cribricollis* specimens were collected, 75% of which were from two sandy plots where little vegetation other than moss was present; the other 25% of the specimens collected were from a plot with sandy soils and sparse bushes, mostly covered by grass. Our results agree with previously published accounts of this species' habitat associations. It is unknown how widespread this species is distributed in the state. Given that the agriculture-associated collecting done in interior Alaska by the USDA station in Palmer during the mid-1900s sampled less than 20% of the state's carabid fauna (Table 3), these two species' status as new records for Alaska is probably an artifact of past under-sampling rather than natural range expansions or human introductions. Nevertheless, it is perplexing that *A. obesa* was so common in our 2006 samples in a region of the state easily accessed by collectors, and yet had remained previously undetected.

Trophic Classifications. The top five most active species (Table 4) are all exclusively predators, with the exception of *D. cognatus*, which is also known to feed on seeds (*Calluna* in Europe), and is thus also granivorous (Larochelle and Lariviere 2003). These species are recorded as known predators of flies (*Ag. cupreum*), lepidopteran larvae (*Ag. cupreum*, *C. ingratus*, and *P. adstrictus*), lepidopteran eggs (*D. cognatus* and *P. adstrictus*), sawfly pupae, dipteran eggs, and elaterids (*P. adstrictus*), and grasshopper eggs and nymphs (*Am. obesa*) (Larochelle and Lariviere 2003).

Activity Density. The high capture rate of one species, *P. adstrictus*, is not uncommon. O'Rourke *et al.* (2008) and Hajeck *et al.* (2007) reported dominant carabid species in studies from Iowa and New York, respectively. *Pterostichus adstrictus* is a habitat generalist, and is found from lowlands to alpine zones,

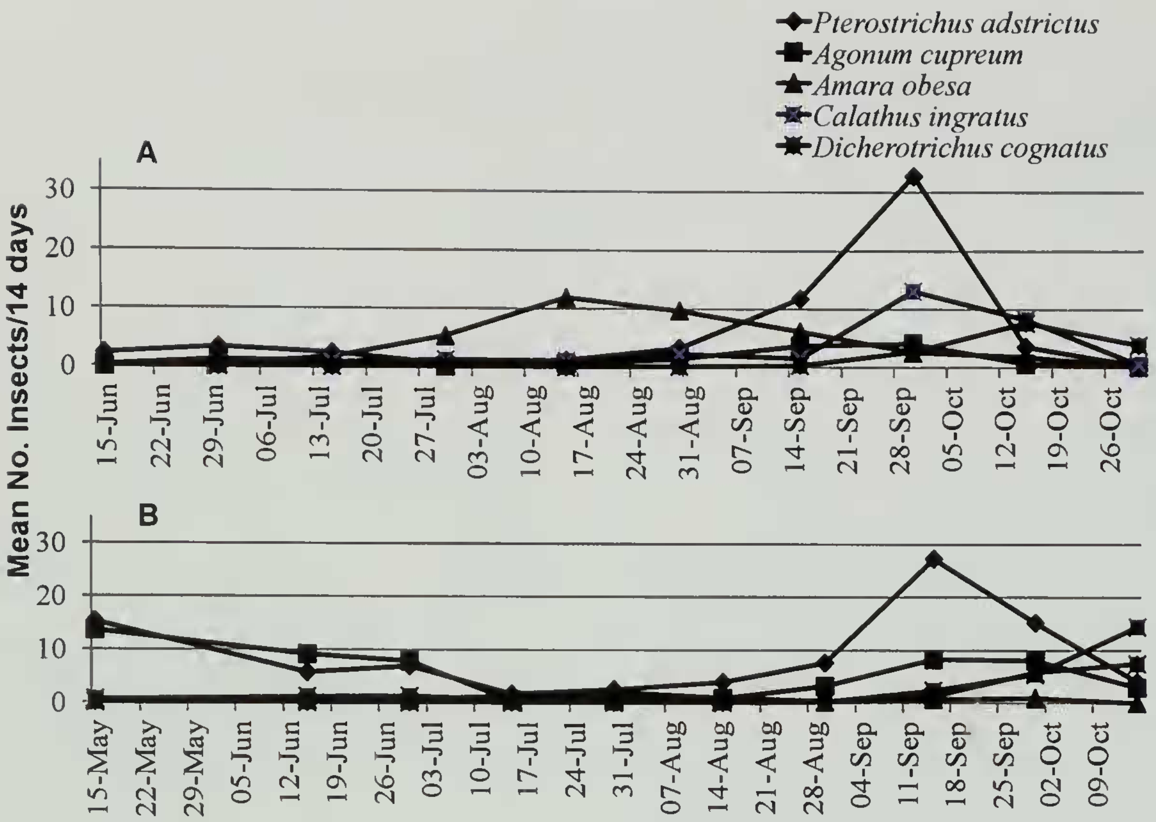

Figure 2. Mean number of *P. adstrictus*, *Ag. cupreum*, *Am. obesa*, *C. ingratus*, and *D. cognatus* per 14-day period, CRP land, Delta Junction, Alaska, USA, 2006 (A) and 2007 (B).

interior forests, grasslands, and coastal zones (Larochelle and Lariviere 2003).

Conservation Reserve Program plots were mowed in 2006 (Seefeldt *et al.* 2010), which might have affected insect relative densities such as the observation that more than three times more *A. cupreum* specimens were collected in 2007 than in 2006. O'Rourke *et al.* (2008) and Hajek *et al.* (2007) reported strong yearly variation in ground beetle populations from disturbed areas in Iowa and New York, respectively. French *et al.* (1998) reported large differences in ground beetle abundances between years, most likely due to differences in rainfall. However, this year- to-year variation is not unusual in Alaska: leafhoppers (Pantoja *et al.* 2009), moths (Landolt *et al.* 2007), click beetles (Pantoja *et al.* 2010a, b), and aphids (Pantoja *et al.* 2010c) displayed significant year-to-year variation in different areas of Alaska, including Delta Junction. The differences in ground beetles' adult-activity densities could not be explained with current knowledge of the biology of this group in the state, but might be associated with relative plant types in the plots. Some carabids are known to consume weed seed (Toft and Bilde 2002; Ward *et al.* 2011), and population size and presence is affected by agronomic practices and the seed bank in natural and managed ecosystems (Menalled *et al.* 2007). Seefeldt *et al.* (2010) reported an increase in plant diversity and increased density of shrubs with increased time in the CRP in Alaska. Ground beetle activity might be affected by reduced grass seed as the shrub densities increase in the plots. However, plant diversity increased at a rate of about two species per 1000 m2 per year (Seefeldt *et al.* 2010), and effects of plant successions on seed bank will not immediately be seen in insect densities. Research is needed to study the possible effects of mowing, plant density, and seed bank on carabid relative densities in subarctic Alaska. Additional research is also needed to understand the components of ground beetles' diets in Alaska CRP lands and to elucidate the possible influence of CRP management practices on their abundance.

Effects on ground beetle abundance by plot variables such as time in the CRP program (Table 4) varied by species. Gobbi and Fontaneto (2008) suggest that the effects of human intervention on ground beetle species' richness are species dependent. O'Rourke *et al.* (2008) elaborated on the possibility of manipulating habitat for carabid diversity and preservation.

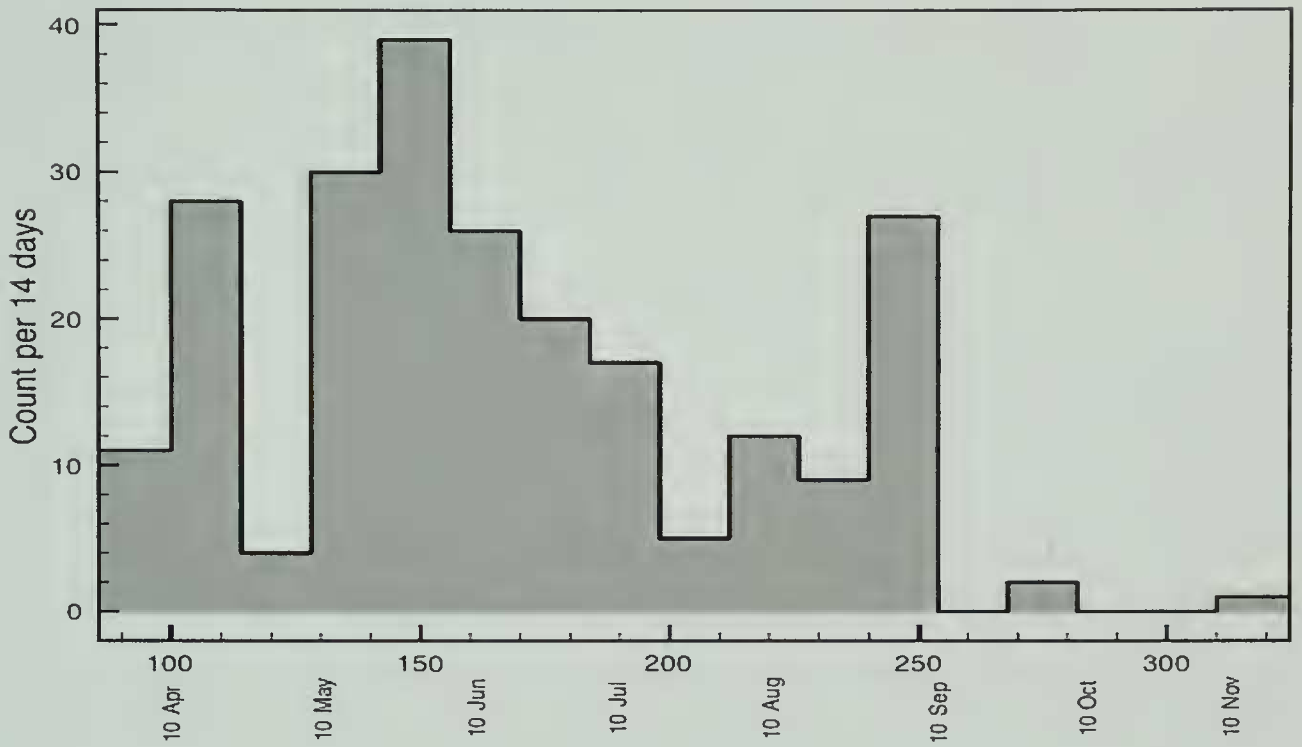

Figure 3. Phenology of Palmer, Alaska, carabidae. Total counts of all carabid species from historic sample (Table 3), with date data (n = 231 specimens) aggregated into 14-day periods from the earliest date across all years.

Late-seasonal adult activity, as we have found for the most abundant species of the CRP sites (Fig. 2) and the historic data (Fig. 3), has been associated with carabid species that overwinter as adults (Hajek *et al.* 2007; Ward *et al.* 2011). In Iowa, carabids were captured until late September, but peak activity was recorded from early June to late July (O'Rourke *et al.* 2008). Our data suggest that mowing CRP plots should occur early in the season, when carabids are less active (Fig. 2).

Historic Data. Only three of the 44 carabid species from the historic Palmer collection are among the sampled CRP fauna. This may seem surprising; however, the entire state's fauna includes more than 240 carabid species, making the lack of shared species among these small samples less remarkable. Not surprisingly, these three species are among the eight most abundant species of the historic dataset. At least *Am. laevipennis* and *Sc. marginatus*, which were also among the top eight most abundant in the historic data, are understandably absent from the CRP data, because these species are known only from south of the Alaska Range. The CRP study site is north of the Alaska Range. *Scaphinotus marginatus* is abundantly collected along the Alaskan coast from the southeast of the state through the Aleutian chain.

To our knowledge, this is the first report on species composition and population dynamics of ground beetles in interior Alaska, and specifically from CRP lands. Information on ground beetles' geographic distribution, population dynamics, dispersal, and biology is needed to understand their roles as predators and seed consumers in natural systems. This study provides some of the information necessary to guide future research in subjects such as species composition, seasonality, a framework for sampling, and time to mow fields. Additional research is needed to study the ecology of the dominant species and their relationships with soil type and CRP management practices, including the pest species on which they are assumed to prey.

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